XXVI. *Some Remarks on the Effects of the late Cold in* February *last: in a Letter from the Rev.* R. Watſon, *Fellow of* Trinity College, *and Profeſſor of Chemiſtry at* Cambridge, *to* Mathew Maty, *M.D. Sec. R. S.*

Dear Sir,

Trin. Coll. Cam. March 21, 1771.

Read April 11, 1771.

ON the 12th of laſt February, about an hour after ſun riſing, I obſerved at Cambridge a degree of cold which is very unuſual in England, though common enough in more northern climates. Fahrenheit's thermometer, made by Dollond, as well in the open air, as when covered with ſnow, ſtood as low as 6° above 0. The Cam, by no means a rapid river, remained unfrozen; at the ſides indeed there was a little ice, and ſome ſmall flakes floating in the middle. This is no very uncommon phænomenon. The Seine was not frozen at Paris in 1709, though the cold continued for two days one degree greater than in the preſent caſe. Various reaſons have been produced, in order to account for this ſeeming deviation from the uſual courſe of nature. It hath been generally believed that

that the ſtrong current in the Seine impeded the congelation: motion will certainly hinder the parts of fluid bodies from acquiring a regular arrangement; but it may be doubted whether it will wholly prevent their coaleſcence, in any caſe where the degree of heat is leſs than what would keep them fluid if they were quieſcent. We have frequent inſtances in chemiſtry, of ſaturated ſolutions of ſalts remaining perfectly fluid whilſt at reſt, and of forming thick coagulums upon the leaſt motion. Melted metals, glaſs, reſins, &c. appear to continue fluid for a longer time, after being taken from the fire, by having their parts moved, than if they are left at reſt; becauſe the ſuperficies which is expoſed to the air is conſtantly changing, and the whole maſs becomes uniformly cold and fixed at once, as ſoon as it has parted with the heat neceſſary for its fuſion. The moſt rapid rivers would probably experience a ſimilar change, did the cold in the atmoſphere continue long enough to be communicated to the whole body of the water: for upon taking the thermometer out of the ſnow, which laid upon the bank of the river, and immerſing it into the water, it ſuddenly roſe 26°, and ſtood at 32°, or higher; ſo that the air was very conſiderably colder than the water: nor is this at all to be wondered at, when we conſider that great degrees of cold may be ſuddenly produced in the atmoſphere by cauſes which do not immediately operate upon other bodies. Thus the influx of colder air from the northern latitudes, or the deſcent of that which always remains exceedingly cold in the upper parts of the atmoſphere in the ſame

ſame latitude, may in a few hours wholly change the air of a particular diſtrict: or, if from any peculiar circumſtance the air ſhould become unuſually dry, and conſequently diſpoſed to diſſolve much water, a great degree of cold might be almoſt inſtantaneouſly produced; but which could not be communicated to other bodies, in a little time, by ſo rare a fluid as the air.

During the forementioned degree of cold, a thick vapour was ſeen riſing from the ſurface, and marking as it were the courſe of the river. If we attribute the elevation of this vapour to the attraction of the air, rather than to the comparative warmth of the water (for water juſt beginning to freeze is obſerved not to loſe of its weight by evaporation *in vacuo*) the great cold may be thought perhaps to have proceeded from the ſolution of water in air which was then carrying on; for the earth was glutted with humidity, and the air was become dry, having been freed from its water by an almoſt inceſſant precipitation for three days, under the form of ſnow or ſleet. It is very remarkable, that the extreme cold of January 13, 1709, came on at Paris, with a gentle ſouth wind, and was diminiſhed when the wind changed to the north; this is accounted for by M. de la Hire, from the wind's having paſſed over the mountains of Auvergne to the ſouth of Paris, then covered with ſnow; and by Mr. Homberg, from the reflux of that air, which had been flowing for ſome time from the north. I do not ſee from what philoſophical principle it can be ſuppoſed, that the ſame air in its regreſs from a ſouthern latitude ſhould

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be colder than in its progreſs from a northern; and as to the other opinion, the phænomenon of the cold's increaſing upon the wind's changing from north to ſouth, hath been taken notice of in other places, where there was no ſnow to refer it to. May it not deſerve to be conſidered, whether the ſudden ſolution of large quantities of aqueous vapours, brought from the ſouth into a dry northern air, be not a cauſe adequate to the effect produced? The ſolubility of water in air is diſtinctly mentioned by Dr. Halley, in the Philoſ. Tranſ. N° 192; and in the 6th Vol. of the French Encyclopedie, publiſhed in 1756; and more fully and ingeniouſly treated of by Dr. Hamilton in 1765: the cold attending the ſolution is a phænomenon ſimilar to that attending many other chemical ſolutions, and is in a leſs degree ſenſibly felt by every one who goes into a room newly waſhed, or ſtreet in the ſummer time lately watered.

Upon taking the thermometer out of the river, its bulb was quickly covered with a thin cruſt of ice, which defended it ſo much from the cold ſubſiſting in the atmoſphere, that it did not ſink two degrees in ten minutes; whereas, when it was wiped dry after immerſion in water, it ſunk above 20° in a leſs ſpace of time: this circumſtance ſhews that ice doth not tranſmit cold, and is explained by the experiments of M. Richmann, who hath eſtabliſhed it as a principle, that metallic ſubſtances are far more quickly affected in their dimenſions by the tranſitions from heat to cold, and the contrary, than any other bodies yet known.

Being desirous of observing the effect of this extraordinary degree of cold upon various saline solutions, I hastened to my elaboratory, where I happened to have a great many solutions of salts corked up in quart bottles; the bottles were not all full, but the solutions were perfectly saturated; the state in which I found them is expressed in the following table.

Frozen wholly	Frozen nearly	Wholly fluid
Alum	Green vitriol	Sea salt
Cream of Tartar	Blue vitriol	Sal gemmæ
Arsenic	Rochelle salt	Sal ammoniac
Corrof. sublimate	Glauber's salt genuine	Volatile alkaline salt
Borax	White vitriol, a few glacial spicula	Fixt alkali per deliq.
Nitre		Epsom salts } Lymington.
		Glauber salts } Lymington.

These experiments agree upon the whole very well with those of professor Braunius, related in the Petersburgh Commentaries for 1763: for, though his saturated solutions of Epsom salts, and of fixt alkali, had begun to freeze in a less degree of cold, yet it is probable that his Epsom salts might have been different from those manufactured at Lymington, and the solution of his fixt alkali not so well saturated as that which is made per deliquium.

During the same frost, I endeavoured to find out the powers, by which different salts, when they are dissolved in water, resist congelation. With this view I dissolved equal weights of salts, equally dry, in equal quantities of water, and exposed the solu-

tions, when they were arrived at the ſame degree of heat, in veſſels of equal and ſimilar figures to the ſame freezing atmoſphere; and accurately marking the times in which they began to freeze, I found them obſerving the following order: firſt alum, then Rochelle ſalt, green vitriol, ſugar refined, white vitriol, vitriolated tartar, Glauber's ſalt, mineral fixt alkali, nitre, blue vitriol, volatile alkali, ſal ammoniac, laſt of all, ſea ſalt. Theſe experiments were repeated once or twice with ſome attention; yet I would not be thought to propoſe the order in which I have arranged the ſeveral ſalts, as wholly to be relied on. It were to be wiſhed, that a ſufficient number of experiments were accurately made upon this ſubject; ſome general truths relative to metallic earths, and alkaline neutral ſalts, would probably be obtained therefrom, which, however unimportant in themſelves, might ſerve, upon ſome occaſion or other, as connecting links, to extend the chain of our ideas. By this compariſon of equal quantities of different ſalts diſſolved in equal quantities of water, we might be enabled to ſpeak with as much preciſion, concerning the powers by which they reſiſt congelation, as we do concerning thoſe by which they reſiſt putrefaction. I know not whether it may not be thought too curious a remark to obſerve, that the Ocean is impregnated with that ſpecies of ſalt which reſiſts congelation with the greateſt power, and in ſuch a quantity as tends not to preſerve entire, but to accelerate the diſſolution of the numberleſs animals which are daily dying in it. Beccher, it hath been aſſerted, was acquainted with this property of common ſalt;

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but he ſeems only to ſpeak of it as a far leſs efficacious anti-ſeptic than ſugar; at leaſt, the honour of aſcertaining the proportion in which it acts as a ſeptic undoubtedly belongs to Sir John Pringle; for Beccher, in his *Phyſica Subterranea, lib.* I. *ſect.* v. *cap.* 1. where he is ſpeaking of this matter, ſays, "quod "nimius ſalis uſus corpus putreſcere faciat, ſicut "modicus a putredine præſervat."

To a table exhibiting the relative powers of neutral ſalts in reſiſting congelation, another might be uſefully added, denoting the powers of all the known acids and alkalies when diluted to a given denſity; as alſo of vinous ſpirits, from highly rectified ſpirits of wine to water impregnated with the minuteſt quantity of ſpirit. Not but that it may be conjectured *a priori*, that in this laſt caſe the reſiſtance to congelation would be directly as the quantity of ſpirit contained in given quantities of water. I made an experiment of this kind with ſea ſalt; in equal quantities of water were diſſolved quantities of ſea ſalt, increaſing in the arithmetical progreſſion, 0, 5, 10, 15, 20, &c.; the times in which the ſolutions began to freeze, reckoning from the time in which ſimple water began, increaſed accurately in the ſame progreſſion: hence it may be inferred, that, in ſalt of the ſame kind, the reſiſtance to congelation is in the direct ſimple proportion of the quantity of ſalt diſſolved; this concluſion cannot be extended to ſalts of different kinds, ſince water ſaturated with ſea ſalt is more difficultly congealed than when ſaturated with various other ſalts, which it diſſolves in greater quantities.

These obſervations, which are only propoſed as hints to thoſe who have more leiſure for experimental enquiries, you will be ſo obliging as to communicate to the Royal Society, or not, as you think proper. I am,

Dear Sir,

Your moſt faithful

and obedient ſervant,

R. Watſon.